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CALIFORNIA INSTITUTE OF TECHNOLOGY

EARTHQUAKE RESEARCH LABORATORY

Analysis of the Taft Accelerogram of the Earthquake of 21 July 1952

by

G. W. Housner

A REPORT ON RESEARCH CONDUCTED UNDER

CONTRACT WITH THE OFFICE OF NAVAL RESEARCH

September 1953

ANALYSIS OF THE TAFT ACCELEROGRAM OF THE EARTHQUAKE OF 21 JULY 1952

by

G. W. HOUSNER

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ANALYSIS OF THE TAFT ACCELEROGRAM OF THE EARTHQUAKE OF 21 JULY 1952

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ABSTRACT

In a previous report of work done under contract with the Office of Naval Research there were presented the spectra of all suitable strong-motion earthquake accelerograms recorded prior to August, 1951. On July 21, 1952 a strong earthquake occurred in the region of Arvin and Tehachapi, California. The ground accelerations were recorded at Taft, California on an instrument maintained by the U.S. Coast and Geodetic Survey. The present report gives the spectra as computed from the Taft accelerograms.

ANALYSIS OF THE TAFT ACCELEROGRAM
OF THE EARTHQUAKE OF 21 JULY 1952

INTRODUCTION

A precise engineering study of the effects of earthquakes on structures must be based on instrumental records of the ground motion. This is not to say that investigations of damaged structures are not important, but since the ground motion is different in every earthquake and since a large number of structures of different types is involved, it will require many destructive earthquakes to amass a sufficient amount of information to permit more or less general and precise conclusions to be reached. From strong-motion earthquake records certain precise information can be deduced which throws considerable light on the effects of ground motion on structures.

When a structure is subjected to ground motion it is excited into a more or less violent vibration with consequent reversals of stresses. The intensity and character of the vibrations of the structure will depend upon the form of the ground motion and also upon the physical properties of the structure, such as size, shape, mass, stiffness, damping, etc. To illustrate just how a structure responds to ground motion some experimental results are presented in the following paragraphs.

MEASURED RESPONSE OF A STRUCTURE TO GROUND MOTION

During an earthquake the slipping that takes place along an earthquake fault generates stress waves that travel through the earth's crust. When these stress waves pass a point on the surface of the ground they excite it into an oscillatory type of motion and this in turn induces a vibration of any structure which is resting on the ground at this point. Stress waves may also be produced in other ways than by a slipping along an earthquake fault. The ground motion shown in Figure 2 was generated by the detonation of 370,000 lbs. of buried explosives.* The horizontal component of ground acceleration shown in Figure 1 was measured at a distance of approximately 1000 ft. from the point of detonation; the maximum acceleration at this location was 8% of gravity. The accelerometer that recorded this motion was located on the floor of the sub-basement of a steel-frame mill building. The walls and floors of the sub-surface portion of the building were reinforced concrete, thus forming a rigid box upon which the steel frame was supported. The roof and siding of the building were of corrugated iron. At an elevation of 45' 8" above the ground floor there was a 6 inch thick concrete floor slab (37' x 65'). This slab, which was the heaviest element of the building, was restrained against lateral motion by cross-bracing (4" H 10#) located in the walls. The building, designed to resist earthquakes, is shown in Figure 1.

The elevated concrete floor slab was so heavy compared to the remainder of the building that the vibration induced by ground motion was essentially that of single heavy mass restrained elastically by the cross-bracing with slight modification due to interaction with the adjacent self-braced one story portion. The ground motion shown in Figure 2 excited the building into vibration and this was measured with an accelerometer located on the elevated concrete floor slab (45' 8" above the

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* Response of a Structure to an Explosive-Generated Ground Shock, by D. E. Hudson, J. L. Alford, and G. W. Housner, ONR Report, California Institute of Technology, September 1952.

Figure 1a. Looking west at steel-frame mill building. Explosion occurred at face of hill just left of upper part of building.

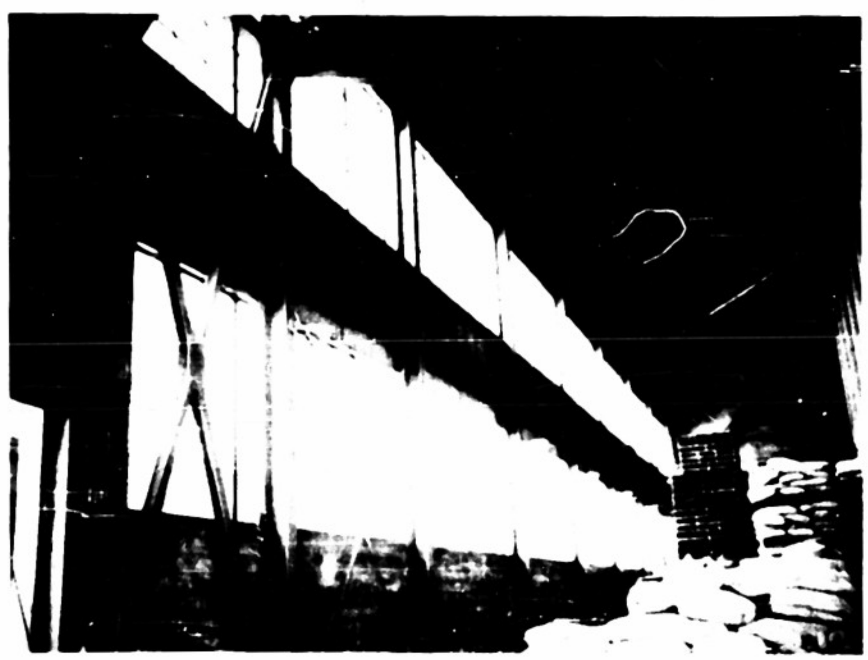

Figure 1b. South wall of mill building.

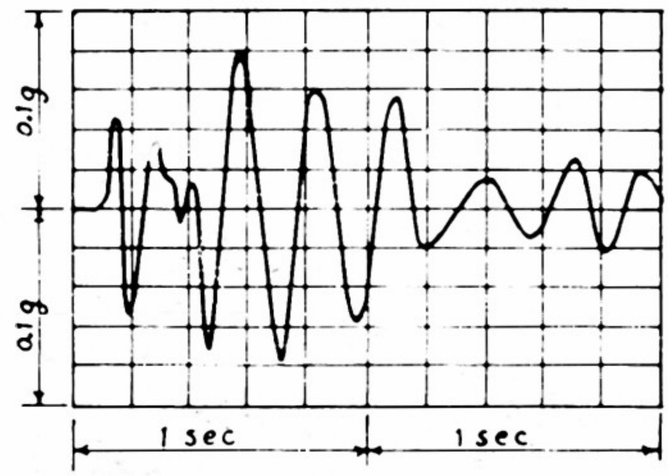

Figure 2. East-west ground acceleration.

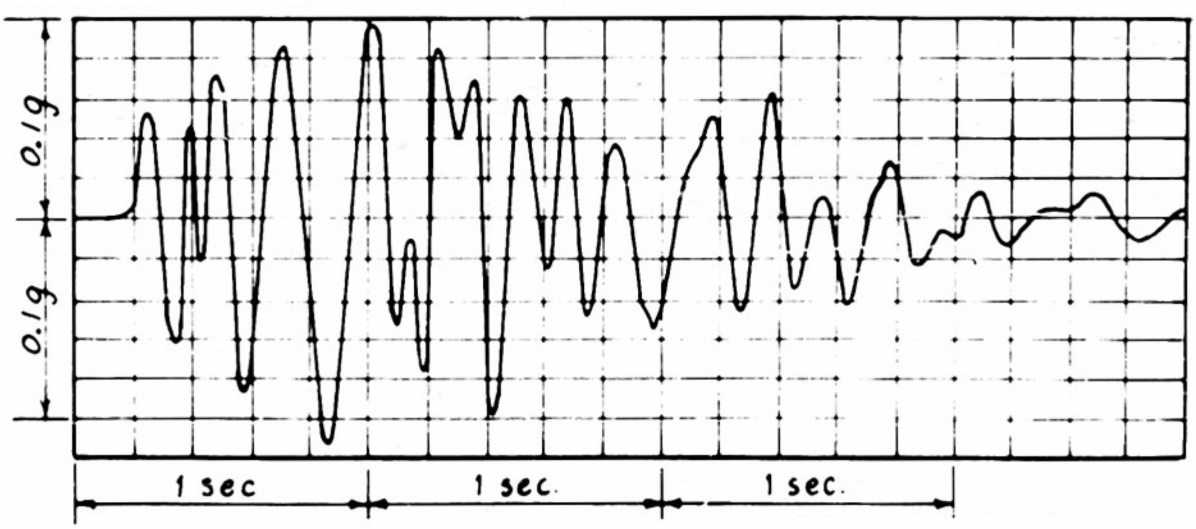

Figure 3. East-west acceleration at upper floor of the mill building.

ground floor). The recorded motion is shown in Figure 3. It is seen that the maximum horizontal acceleration of the floor slab was 10.5% of gravity. The strong ground motion lasted only for one second, and during this time the vibrations of the building increased, and subsequent to this time the vibrations decreased gradually. The natural period of vibration of the structure was approximately 1/3 of a second.

The ground motion of Figure 2 is similar to that of a moderately strong but very short duration earthquake. For comparison there is shown in Figure 4 the initial portion of the north-south ground acceleration recorded at Hollister, California during the earthquake of March 9, 1949. The Hollister shock was a moderate earthquake and in contrast to it the maximum acceleration recorded at El Centro, California during the earthquake of May 18, 1940 was 33%g and the duration of the strong motion was approximately 25 seconds. If the building had been subjected to the El Centro ground motion the vibrations would have been much more severe than those shown in Figure 3.

In view of the fact that the motion of the building depends upon its mass, stiffness and damping it is of interest to investigate what difference in motion there would be if, for example, the stiffness of the bracing had been greater, or if there had been more or less damping. Variations in the mass and stiffness have an effect on the period of vibration of the structure, so if the vibrations are investigated for a range of different values of period of vibration and damping, the effect of mass, stiffness and damping will be determined. It is of particular interest to know the maximum acceleration experienced by the building for various periods of vibration and various values of the damping. These have been calculated and are shown in Figure 5.

The three curves in Figure 5 labelled n = 0.02, 0.05, 0.10, represent different values of damping, n being the fraction of critical damping. The ordinates of these curves represent the maximum acceleration of the elevated floor slab corresponding to any particular natural period of vibration and to

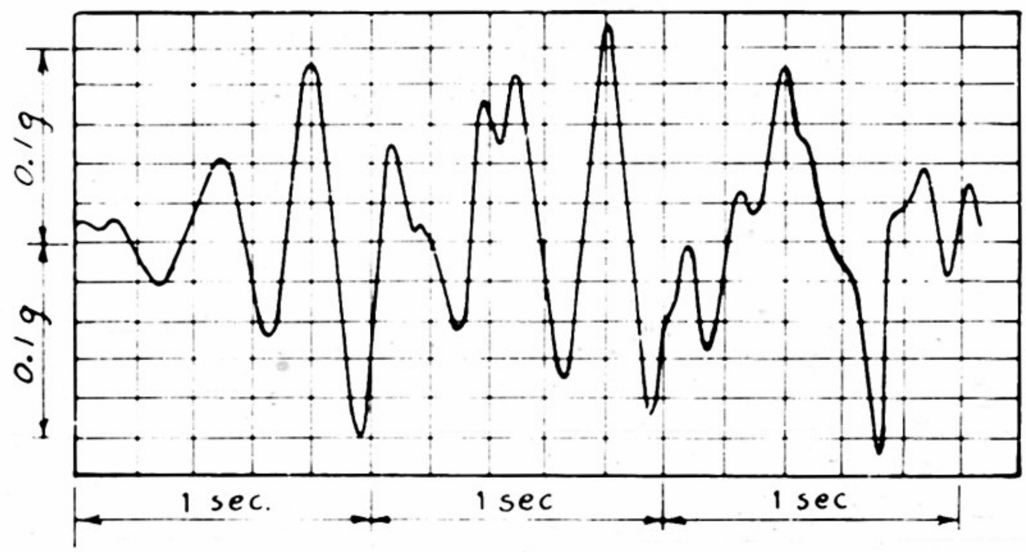

Figure 4. Initial portion of the north-south ground acceleration recorded at Hollister, California during the earthquake of March 9, 1949.

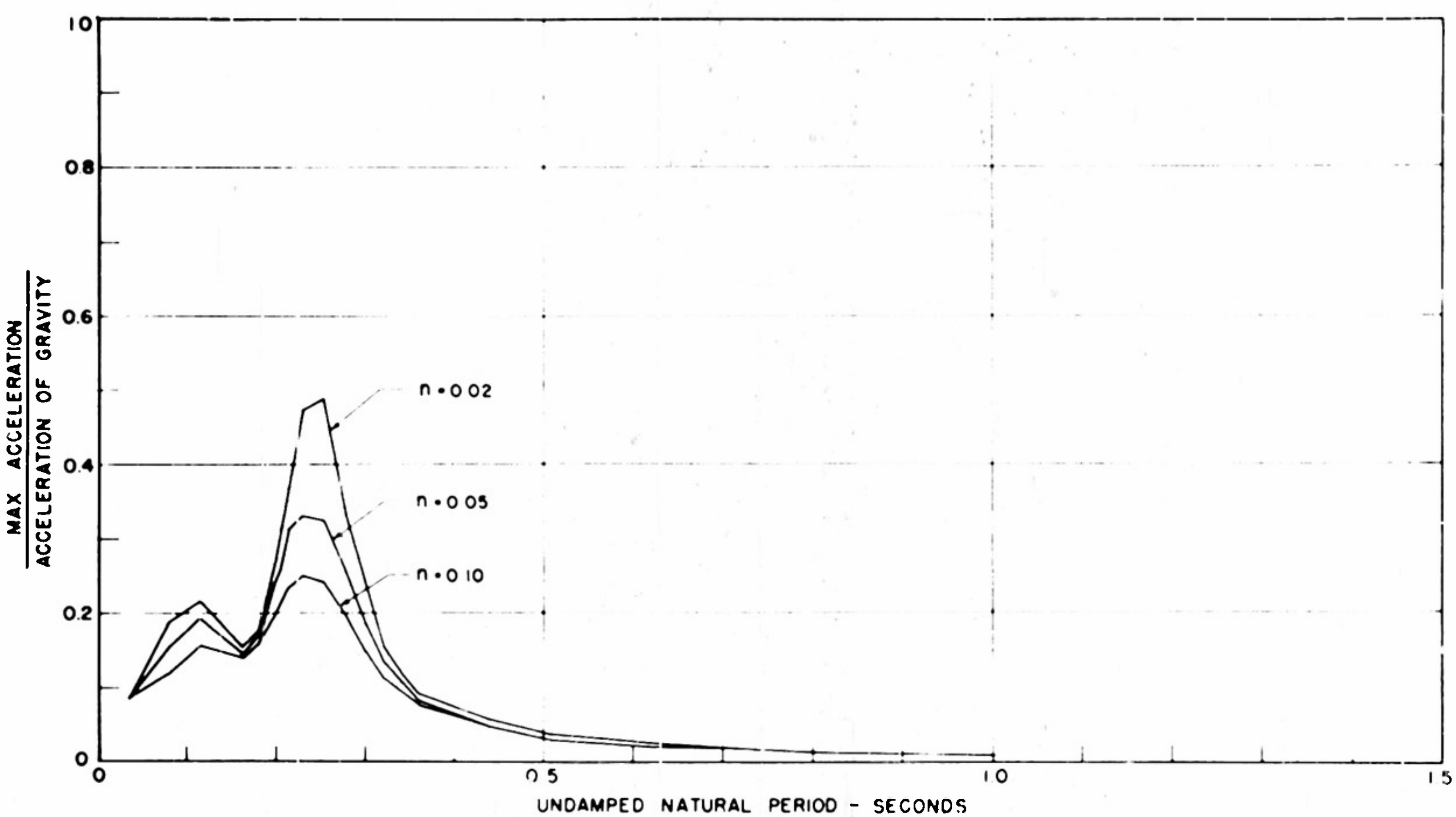

Figure 5. Acceleration spectra for Corona quarry blast, July 26, 1952. Component E-W.

various values of damping. For example, the actual building had a natural period of vibration of 1/3 second and had a relatively low damping. Reading from the n = 0.05 curve for a period equal to 1/3 second there is obtained a maximum acceleration of 10.5%g which corresponds to the actual measured value as shown in Figure 3. If the bracing of the elevated floor slab were stiffer so that the period of vibration was 0.3 seconds with n = 0.05, the vibration of the building would have been more severe and the maximum acceleration as shown by Figure 5, would have been 20%g. On the other hand, if the bracing were very flexible so that the period of vibration was 0.5 seconds, the maximum acceleration would have been 3.5%g.

It can be seen from Figure 5 that the behavior of the building when subjected to ground motion depends very strongly upon its physical properties and that if there were two such buildings identical in all respects except for stiffness of bracing and damping, their response to the same ground motion could be very different.

The curves of Figure 5 can also be applied to buildings other than the mill building. For example, if it were desired to know how the ground motion of Figure 1 would affect a five story office building the curves of Figure 5 can be used The curves represent the response of the first mode of vibration according to the period and damping. The curves represent the maximum acceleration of the first mode of vibration, however the scale of %g would have to be changed; for each particular type of building there would be a different numerical scale of %g. The same remarks apply to the second mode of vibration and again there would be a different numerical scale of %g for each type of building. It is thus seen that Figure 5 characterizes the ground motion as to its effect on structures. Any structure having a period of approximately 0.25 seconds and small damping would experience a relatively large acceleration as compared to a structure of the same type having a period of 0.5 seconds, etc. The curves of Figure 5 are called acceleration spectra because they give the maximum acceleration as a function of the period of vibration.

THE ARVIN-TEHACHAPI GROUND MOTION

The effect of ground motion on structures is characterized by the spectrum curves of the ground motion so that it is very informative to study the spectra of earthquake ground motions. These curves enable one to make a rather precise comparison of the intensities of ground motion of different earthquakes, and they also indicate the maximum stresses likely to be developed during a shock. Such curves have been published in the Bulletin of the Seismological Society of America* for a large number of strong earthquakes occurring prior to 1950. The curves for the Arvin-Tehachapi shock are presented here.

The ground motion of the Arvin-Tehachapi shock was recorded by the U.S. Coast and Geodetic Survey at Taft, California. This is approximately 30 miles from the epicenter of the shock which was at Wheeler Ridge. The ground motion at Taft was less severe than at points closer to the epicenter. It is estimated that the ground motion a few miles north of Wheeler Ridge had an intensity approximately twice as severe as at Taft. The recorded ground motion at Taft is shown in Figures 6 and 7. For comparison, one component of the ground motion at El Centro, California during the earthquake of May 18, 1940 is shown in Figure 8. It is seen that the Taft ground motion was much less severe than the El Centro ground motion.

The acceleration spectra for the Taft record are shown in Figures 9 and 10 and for comparison the spectra of El Centro shock are shown in Figure 11. It is seen from these that the Taft ground motion was approximately one-half as intense as the El Centro ground motion, that is, a building subjected to the Taft ground motion would have experienced maximum stresses approximately one-half as great as it would have had it been subjected to the

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* Spectrum Analysis of Strong-Motion Earthquakes, by G. W. Housner, R. R. Martel, and J. L. Alford, Bull. Seism. Soc. Amer., Vol. 43, No. 2, April 1952.

Spectrum Analysis of Strong-Motion Earthquakes, by G. W. Housner, R. R. Martel, and J. L. Alford, Office of Naval Research Report, Contract N6 onr-244, Task Order 25, California Institute of Technology, August 1951.

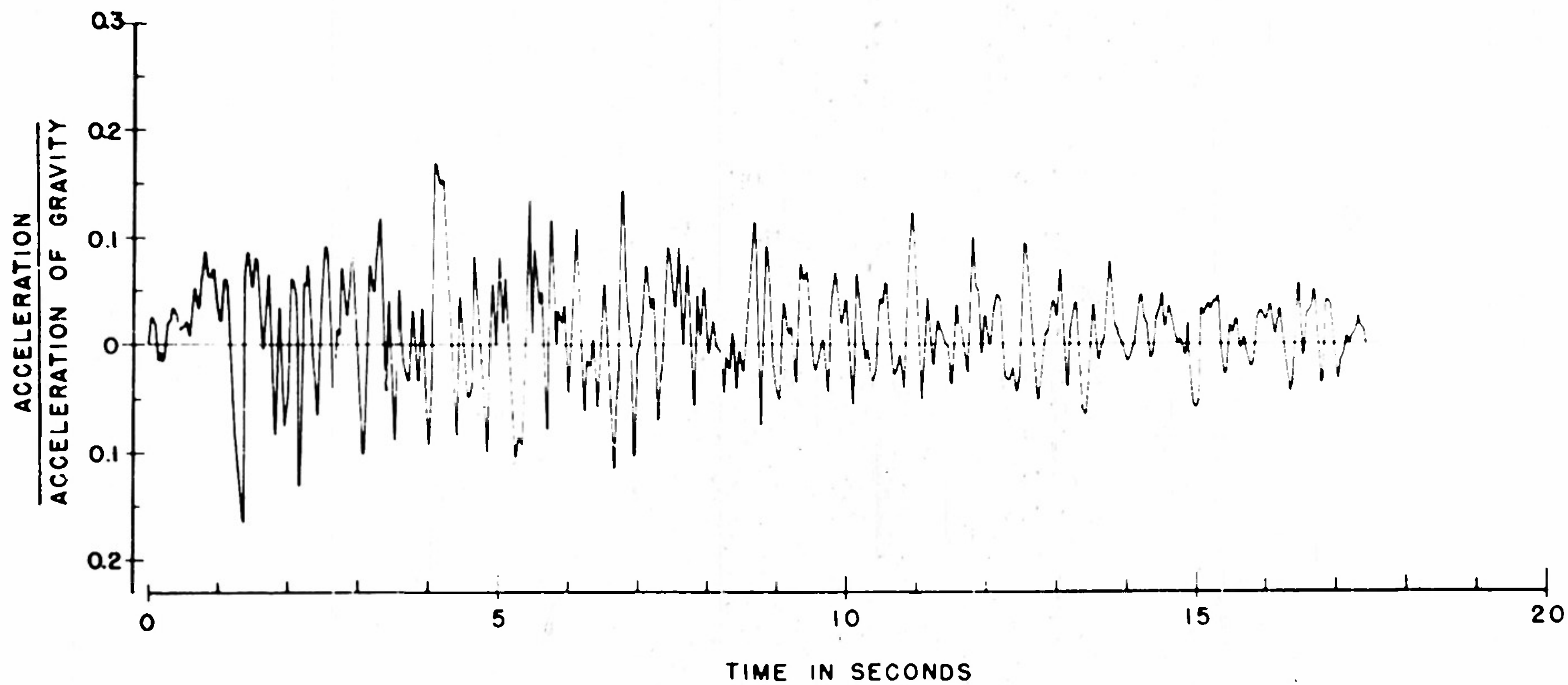

Figure 6. Accelerogram for Taft, California; earthquake of July 21, 1952. Component S69E.

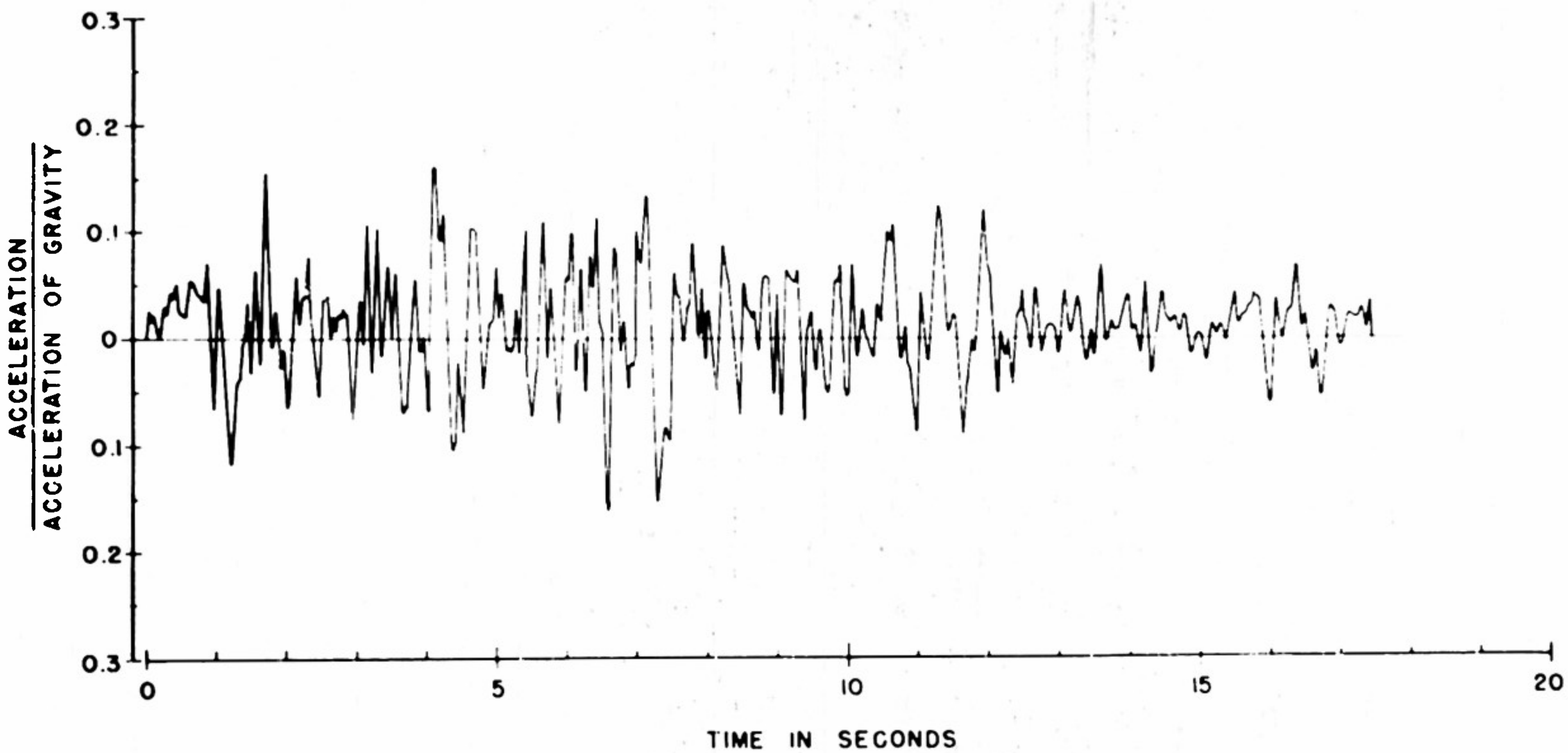

Figure 7. Accelerogram for Taft, California earthquake of July 21, 1952. Component N21E.

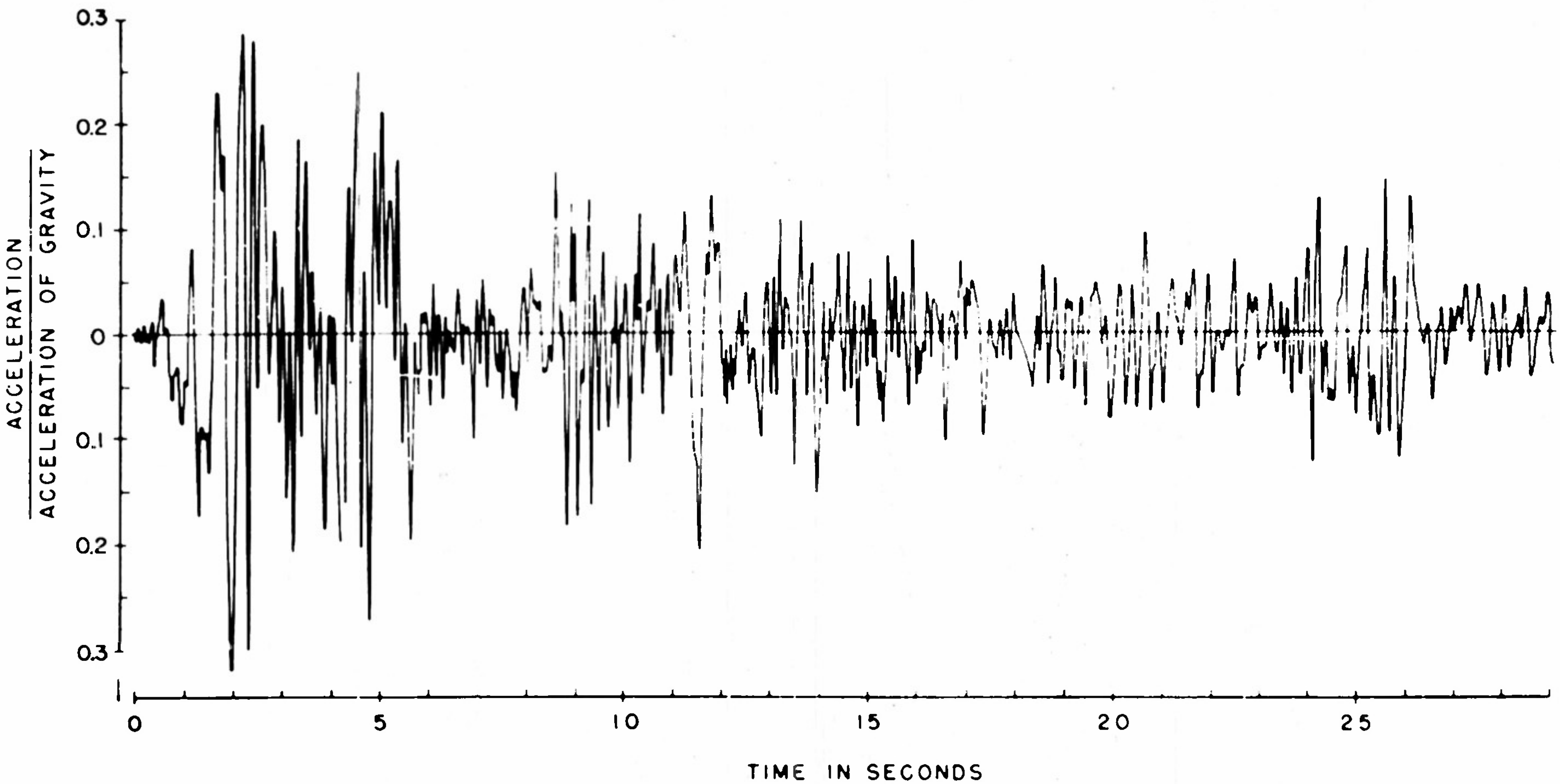

Figure 8. Accelerogram for El Centro, California; earthquake of May 18, 1940, Component N-S.

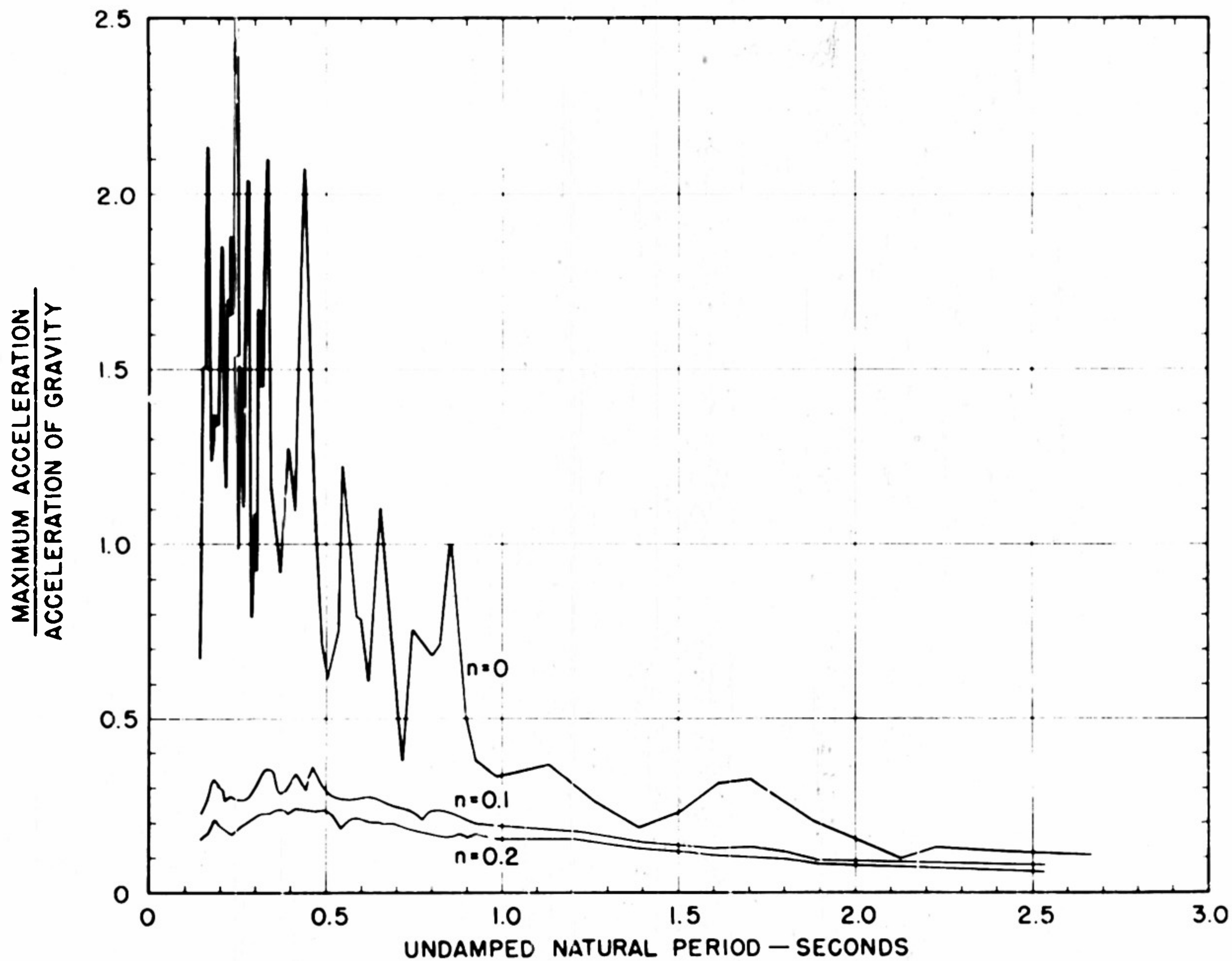

Figure 9. Acceleration spectra for Taft, California; earthquake of July 21, 1952. Component S69E.

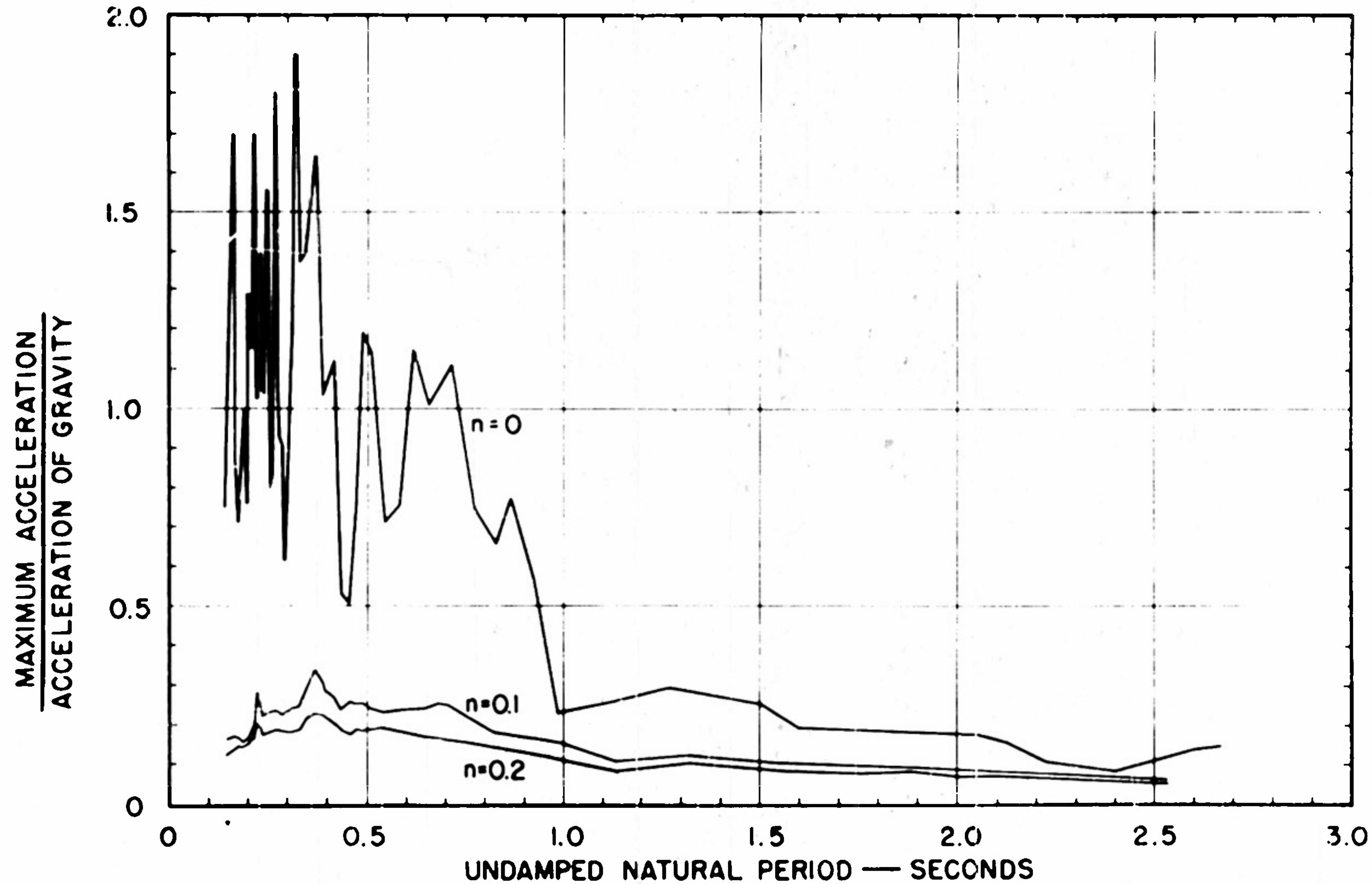

Figure 10. Acceleration spectra for Taft, California; earthquake of July 21, 1952. Component N21E.

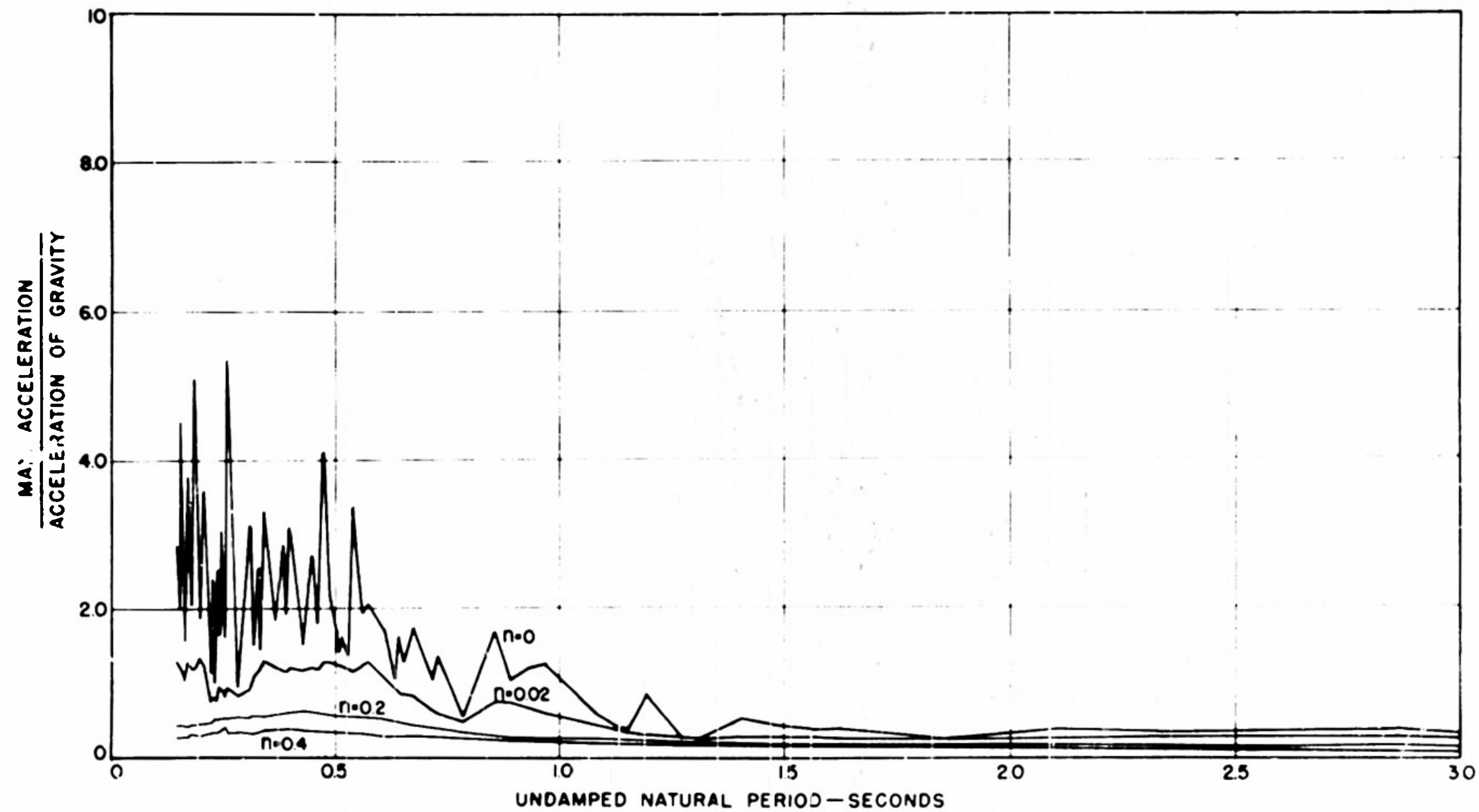

Figure 11. Acceleration spectra for El Centro, California; earthquake of May 18, 1940. Component N-S.

El Centro ground motion. Furthermore, the spectra show that the character of the Taft ground motion was similar to that of the El Centro ground motion for the spectra curves have similar shapes for both shocks.

According to seismologists the magnitude of the Arvin-Tehachapi shock was 7.5 and that of the El Centro shock was 6.7. The energy released by a shock is related to the magnitude by the expression*

$$E = (10)^{11.3} \quad (10)^{1.8M}$$

where E is the energy in ergs and M is the magnitude. According to this, 28 times as much energy was released by the Arvin-Tehachapi shock as by the El Centro shock. Other things being equal, this would require the ground motion of the Arvin-Tehachapi shock to be very much more severe than the ground motion of the El Centro shock. However, it appears that actually the ground motion of the Arvin shock was somewhat less than that associated with the El Centro shock. This can only mean that there was some significant difference in the processes of energy release of the two shocks. The El Centro earthquake was typical of the usual California earthquake in that it was generated by a horizontal slipping along an essentially vertical fault plane, whereas the Arvin-Tehachapi shock was apparently generated by a slipping that was essentially vertical. Presumably this type of slipping, combined with the geological conditions of the region, produced less intense ground motion in the epicentral region than would normally be expected for an energy release of that magnitude.

VELOCITY SPECTRA

An alternate way of presenting the data given by the acceleration spectra of Figures 9 and 10 is to multiply each ordinate by $\frac{T}{2\pi}$, where T is the period

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* Earthquake Magnitude, Intensity, Energy and Acceleration, by B. Gutenberg and C. F. Richter, Bull. Seism. Soc. Amer., Vol. 32, No. 3, July 1942.

of vibration. When the maximum acceleration of a one degree of freedom structure is multiplied by $\frac{T}{2\pi}$ there is obtained essentially the maximum velocity of the structure. When these are plotted there are obtained the so-called velocity spectra. Since the maximum velocity of a one degree of freedom structure is proportional to the square root of the maximum kinetic energy, the velocity spectrum is a measure of the maximum vibrational energy of the structure. The chief advantage of plotting the velocity spectrum is that the ordinates do not become small with increasing period as they do for the acceleration spectrum, and thus the velocity spectrum is easier to read. The velocity spectra for the Taft ground motion are shown in Figures 12 and 13. For comparison the velocity spectra for the El Centro shock are shown in Figure 14. The numerical values for both the acceleration and velocity spectra for the Taft ground motion are presented in the appendix.

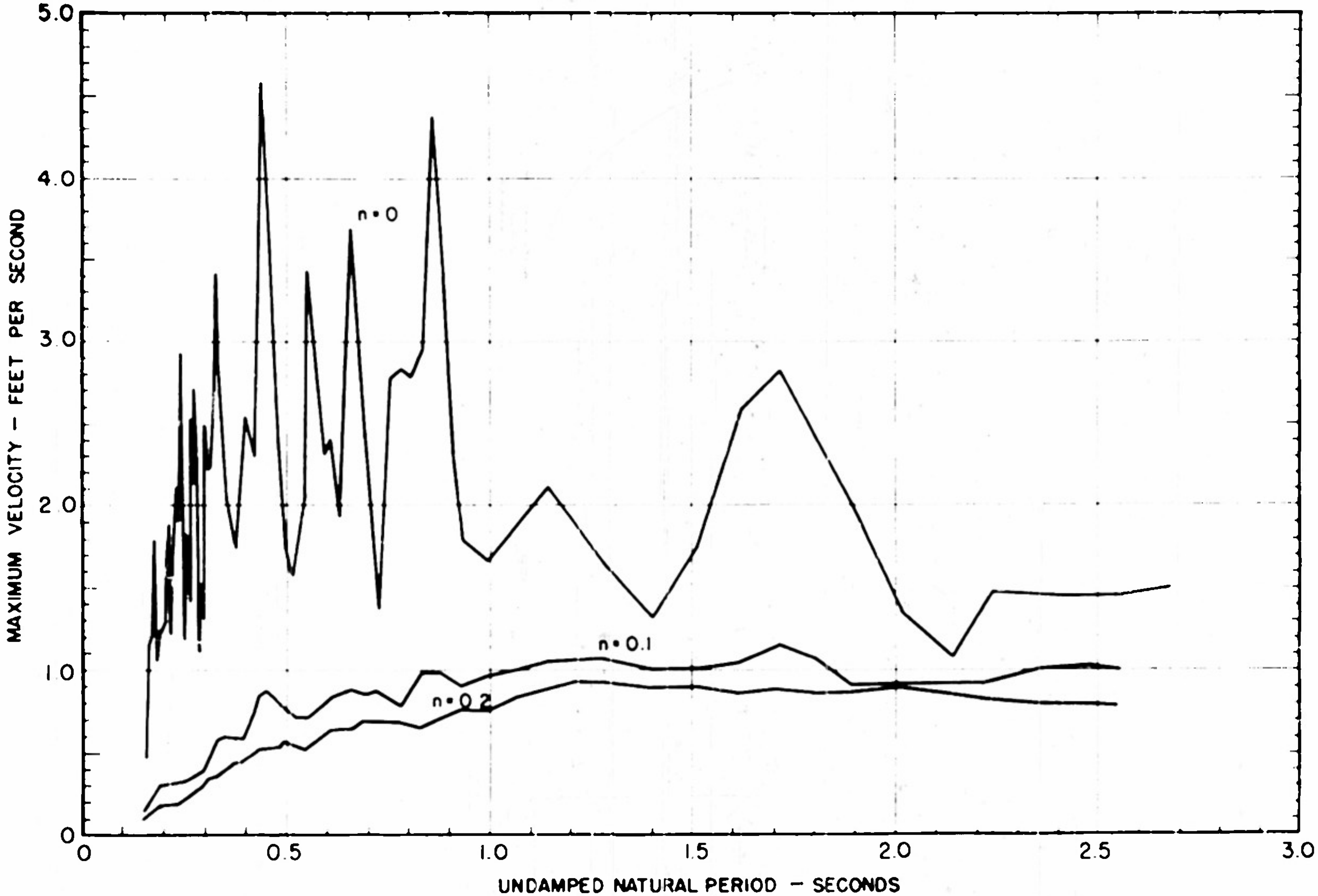

Figure 12. Velocity spectra for Taft, California; earthquake of July 21, 1952. Component S69E.

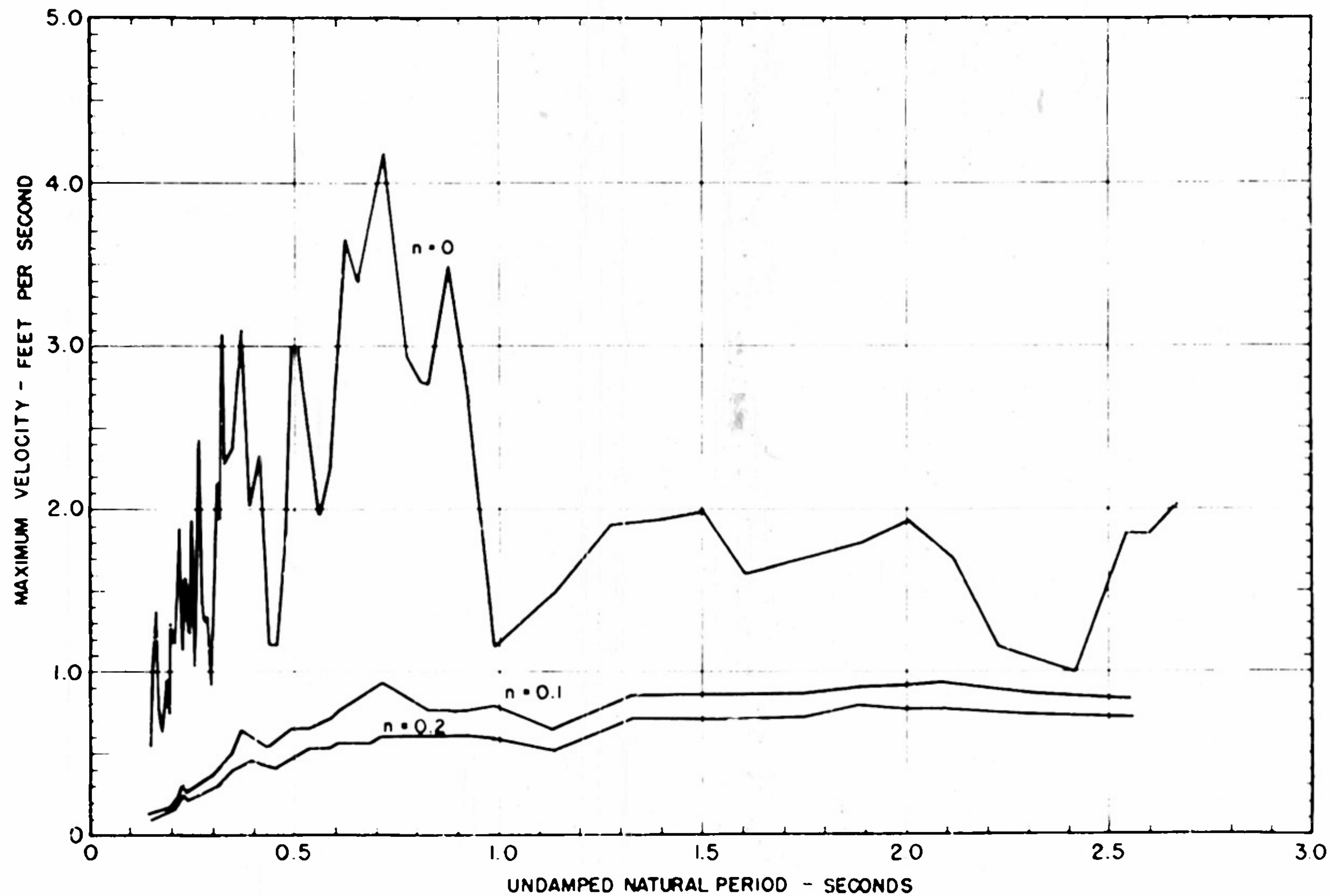

Figure 13. Velocity spectra for Taft, California; earthquake of July 21, 1952. Component N21E.

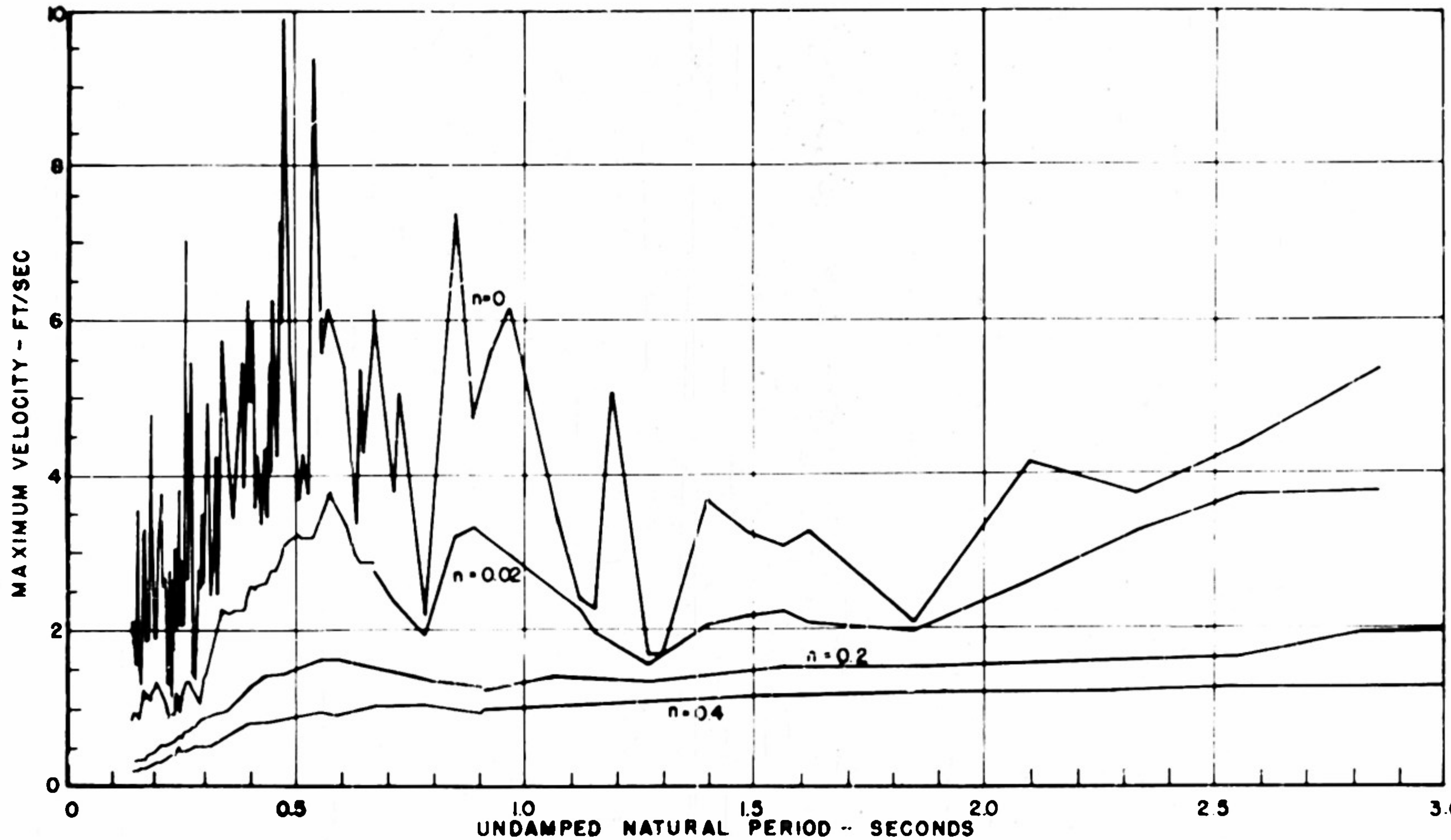

Figure 14. Velocity spectrum for El Centro, California; earthquake of May 18, 1940. Component N-S.

APPENDIX I

Definition of Earthquake Spectrum

Consider a structure that has linearly elastic, damped vibrations so that during a free vibration the displacement, y, at any point of the structure is given by the sum of the normal modes of vibration

$$y = \sum_i c_i \phi_i \, e^{-n_i p_i t} \sin p_i t \tag{1}$$

in which

c_i = undetermined coefficient

ϕ_i = i^{th} normal mode

p_i = 2π times the frequency of the i^{th} mode

n_i = ratio of damping in i^{th} mode to critical damping

t = time

If the free vibrations are initiated so that at time $t = 0$ the displacement is zero and the velocity is v_o at every point of the structure, then the coefficients are evaluated in the Fourier manner, namely,

$$c_i = \frac{v_o}{p_i} \, \frac{\int \phi_i \, dp}{\int \phi_i^2 dp} = \frac{v_o}{p_i} \, W_i \tag{2}$$

in which p is the density and the integrals are taken over the entire mass of the structure. The corresponding free vibrations are then

$$y = \sum_i \frac{v_o}{p_i} \, W_i \, \phi_i \, e^{-n_i p_i t} \sin p_i t \tag{3}$$

If, now, the base of the structure be subjected to a variable acceleration a, the displacement at time t is given by

$$y = \sum_i \frac{W_i}{p_i} \, \phi_i \int_o^t a \, e^{-n_i p_i (t-\tau)} \sin p_i (t-\tau) d\tau \tag{4}$$

This may be written

$$y = \sum_i \frac{W_i}{p_i} \phi_i X_i \tag{5}$$

in which

$$X_i = \int_0^t a\, e^{-n_i p_i (t-\tau)} \sin p_i (t-\tau) d\tau \tag{6}$$

It should be noted that the factor W_i/p_i is a function only of the physical properties of the structure, that is, mass, rigidity, and dimensions. The factor ϕ_i is a function of the space coordinates, and the factor X_i is a function of the earthquake (ground acceleration).

From Equation (5) it can be seen that in order to investigate the physical significance of earthquakes it is necessary to evaluate X as a function of (p) and (n). The maximum value of X, for $0 < t < T$, when plotted as a function of p is called the velocity spectrum. A similar plot of $(2\pi pX)$ is called the acceleration spectrum.

APPENDIX H

Spectrum Ordinates for the Taft Ground Motion

T = period of vibration in seconds

v = maximum velocity in ft. per sec.

a = maximum acceleration in ft. per sec^2.

g = acceleration of gravity in ft. per sec^2.

n = fraction of critical damping.

COMPONENT S69E

	n = 0			n = 0.1		n = 0.2	
T	v	a/g	T	v	a/g	v	a/g
0.146	0.502	0.671	0.146	0.114	0.152	0.167	0.223
0.153	1.18	1.505	0.153	0.128	0.163	0.192	0.245
0.1597	1.23	1.50	0.1597	0.138	0.1685	0.217	0.265
0.1663	1.81	2.12	0.1725	0.168	0.190	0.276	0.312
0.1725	1.09	1.23	0.1845	0.192	0.203	0.308	0.326
0.1785	1.26	1.377	0.1960	0.197	0.196	0.310	0.308
0.1845	1.26	1.33	0.206	0.197	0.1865	0.315	0.298
0.1920	1.32	1.34	0.2165	0.197	0.1775	0.298	0.268
0.1960	1.70	1.69	0.231	0.197	0.166	0.325	0.274
0.201	1.90	1.84	0.244	0.221	0.1765	0.338	0.270
0.206	1.23	1.164	0.273	0.276	0.197	0.359	0.264
0.216	1.87	1.69	0.292	0.321	0.208	0.420	0.281
0.211	1.79	1.655	0.309	0.358	0.226	0.512	0.323
0.221	2.12	1.87	0.326	0.369	0.221	0.596	0.357
0.226	1.93	1.665	0.342	0.394	0.225	0.615	0.351
0.231	2.95	2.49	0.369	0.442	0.234	0.518	0.274
0.235	1.86	1.543	0.391	0.452	0.225	0.601	0.300
0.240	1.21	0.983	0.412	0.506	0.240	0.732	0.346
0.244	1.87	1.492	0.443	0.532	0.234	0.893	0.393
0.248	1.79	1.41	0.461	0.538	0.228	0.854	0.361

Component S69E (Contd.)

	n = 0			n = 0.1		n = 0.2	
T	v	a/g	T	v	a/g	v	a/g
0.253	1.44	1.10	0.488	0.578	0.231	0.775	0.310
0.257	2.54	1.925	0.514	0.565	0.214	0.728	0.276
0.261	2.73	2.04	0.546	0.525	0.1875	0.723	0.258
0.269	2.56	1.856	0.576	0.604	0.204	0.775	0.262
0.273	2.31	1.650	0.605	0.643	0.207	0.854	0.275
0.277	1.12	0.789	0.638	0.656	0.201	0.885	0.271
0.280	1.55	1.08	0.653	0.656	0.196	0.885	0.256
0.205	1.32	0.902	0.684	0.695	0.198	0.866	0.247
0.292	2.51	1.676	0.715	0.689	0.188	0.885	0.241
0.299	2.24	1.46	0.743	0.689	0.181	0.885	0.232
0.306	2.26	1.44	0.772	0.689	0.174	0.793	0.201
0.313	2.69	1.675	0.799	0.689	0.168	0.951	0.232
0.320	3.43	2.09	0.825	0.656	0.155	0.997	0.236
0.326	2.82	1.69	0.851	0.668	0.153	0.983	0.225
0.345	2.05	1.158	0.875	0.716	0.1569	0.991	0.221
0.369	1.73	0.913	0.900	0.723	0.157	0.942	0.204
0.391	2.56	1.277	0.923	0.771	0.163	0.912	0.1926
0.412	2.32	1.098	0.984	0.762	0.151	0.971	0.1925
0.433	4.61	2.075	1.064	0.837	0.153	1.01	0.185
0.452	3.41	1.472	1.137	0.897	0.154	1.06	0.182
0.471	2.36	0.977	1.205	0.933	0.151	1.07	0.173
0.488	1.76	0.703	1.270	0.933	0.1435	1.075	0.165
0.506	1.58	0.610	1.392	0.897	0.1257	1.01	0.1415
0.538	2.07	0.751	1.503	0.897	0.116	1.01	0.131
0.546	3.45	1.217	1.607	0.866	0.1055	1.05	0.1275
0.584	2.33	0.778	1.705	0.881	0.101	1.155	0.132
0.600	2.42	0.787	1.797	0.866	0.094	1.075	0.1167
0.620	1.93	0.607	1.887	0.866	0.0895	0.911	0.0942
0.652	3.71	1.11	2.06	0.881	0.0835	0.918	0.0870
0.684	2.42	0.690	2.21	0.822	0.0725	0.933	0.0824

Component S69E (Contd.)

T	n = 0 v	n = 0 a/g	T	n = 0.1 v	n = 0.1 a/g	n = 0.2 v	n = 0.2 a/g
0.715	1.38	0.382	2.35	0.784	0.0615	1.01	0.0838
0.743	2.78	0.755	2.48	0.784	0.0617	1.015	0.0800
0.772	2.84	0.718	2.54	0.777	0.0596	0.992	0.0762
0.798	2.80	0.685					
0.824	2.98	0.706					
0.851	4.38	1.004					
0.876	3.41	0.760					
0.900	2.33	0.805					
0.923	1.79	0.378					
0.985	1.67	0.331					
1.136	2.12	0.364					
1.270	1.645	0.253					
1.392	1.315	0.1842					
1.503	1.743	0.226					
1.607	2.59	0.314					
1.705	2.82	0.322					
1.887	1.99	0.205					
2.06	1.35	0.128					
2.13	1.07	0.098					
2.23	1.47	0.1285					
2.41	1.44	0.1164					
2.54	1.44	0.1105					
2.67	1.50	0.1095					

COMPONENT N21E

	n = 0.00			n = 0.10		n = 0.20	
T	v	a/g	T	v	a/g	v	a/g
0.146	0.563	0.753	0.146	0.094	0.125	0.125	0.167
0.153	1.12	1.30	0.160	0.110	0.134	0.141	0.172
0.160	1.38	1.683	0.1725	0.125	0.141	0.147	0.166
0.166	0.738	0.867	0.1845	0.138	0.146	0.147	0.155
0.173	0.632	0.713	0.1967	0.154	0.1525	0.172	0.1705
0.179	0.715	0.778	0.206	0.172	0.163	0.198	0.187
0.185	0.942	0.991	0.2165	0.188	0.169	0.226	0.204
0.192	0.752	0.763	0.226	0.242	0.209	0.329	0.284
0.196	1.30	1.294	0.235	0.213	0.177	0.270	0.224
0.201	1.19	1.155	0.253	0.242	0.186	0.301	0.232
0.206	1.39	1.315	0.269	0.260	0.189	0.326	0.236
0.211	1.52	1.405	0.277	0.266	0.188	0.326	0.229
0.216	1.88	1.697	0.285	0.270	0.185	0.336	0.230
0.221	1.16	1.022	0.299	0.279	0.182	0.364	0.237
0.226	1.61	1.39	0.313	0.298	0.186	0.392	0.244
0.231	1.25	1.055	0.326	0.308	0.184	0.414	0.248
0.235	1.24	1.03	0.345	0.388	0.219	0.501	0.283
0.240	1.27	1.03	0.369	0.428	0.226	0.646	0.342
0.244	1.96	1.565	0.391	0.452	0.225	0.594	0.296
0.248	1.00	0.787	0.412	0.436	0.207	0.572	0.271
0.253	1.07	0.825	0.432	0.413	0.187	0.534	0.241
0.261	2.43	1.815	0.452	0.413	0.178	0.602	0.260
0.269	1.43	1.037	0.471	0.459	0.190	0.617	0.256
0.277	1.32	0.930	0.488	0.466	0.186	0.647	0.258
0.282	1.35	0.901	0.506	0.481	0.185	0.647	0.249
0.292	0.923	0.616	0.538	0.527	0.191	0.654	0.237
0.299	1.32	0.855	0.604	0.557	0.180	0.752	0.243
0.306	2.17	1.068	0.647	0.549	0.166	0.820	0.247
0.313	1.95	1.215	0.685	0.572	0.163	0.880	0.251

	n = 0.00			n = 0.10		n = 0.20	
T	v	a/g	T	v	a/g	v	a/g
0.320	2.10	1.890	0.715	0.587	0.160	0.925	0.252
0.326	2.28	1.364	0.772	0.602	0.152	0.843	0.213
0.345	2.48	1.401	0.824	0.602	0.142	0.768	0.182
0.369	3.10	1.64	0.876	0.587	0.131	0.768	0.171
0.387	2.02	1.018	0.923	0.602	0.127	0.768	0.162
0.413	2.36	1.112	0.985	0.585	0.116	0.783	0.155
0.433	1.17	0.527	1.136	0.513	0.0883	0.641	0.110
0.452	1.15	0.497	1.33	0.713	0.105	0.855	0.125
0.471	1.79	0.741	1.555	0.698	0.0876	0.855	0.107
0.488	3.00	1.20	1.75	0.713	0.0795	0.869	0.0968
0.506	3.00	1.155	1.883	0.783	0.0812	0.898	0.0930
0.546	1.97	0.704	2.01	0.770	0.0747	0.912	0.0885
0.584	2.25	0.751	2.09	0.770	0.0719	0.926	0.0863
0.620	3.66	1.15	2.31	0.727	0.0614	0.855	0.0722
0.652	3.38	1.01	2.54	0.713	0.0548	0.826	0.0635
0.715	4.18	1.14					
0.772	2.93	0.741					
0.824	2.77	0.656					
0.876	3.49	0.778					
0.923	2.66	0.562					
0.985	1.16	0.230					
1.136	1.50	0.258					
1.270	1.90	0.292					
1.392	1.93	0.270					
1.503	1.98	0.257					
1.607	1.61	0.195					
1.89	1.80	0.186					
2.06	1.93	0.183					
2.13	1.70	0.156					
2.23	1.16	0.103					
2.41	0.992	0.0802					
2.60	1.86	0.1396					
2.54	1.86	0.143					
2.67	2.03	1.48					